Observations and Modeling for Source Characterization

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LONG-TERM GOALS

We propose to continue our work coupling Unmanned Underwater Vehicle (UUV) and other coastal observations with a 3D hydrodynamic model (DELFT-3D FLOW) to investigate circulation and transport of coastal source material. While coastal areas near riverine discharge have traditionally been difficult to sample, UUVs with advanced sensor technology afford the opportunity to systematically study the dynamic components of these systems. Highly resolved measurements of circulation patterns, in water components, bottom topography and characterization will be coupled with the modeling effort. This combination will allow UUV guidance and improve model performance. It is hoped that the integration of mobile systems for localized modeling will be a ‘system’ that is portable to other systems to help advance our understanding of circulation patterns and mechanisms for change in bottom topography and morphology.

OBJECTIVES

The primary goal of this study is to develop a high resolution predictive capability of sources and their advective transport within the Gulf of Catalina and along the shoreline of San Diego County. This will be achieved using a combination of in situ observations and a 3D hydrodynamic model (DELFT-3D FLOW). Source characterization will be conducted using a number of UUVs equipped with appropriate sensors. These sources include riverine inputs from the Tijuana River and two outfall plumes in the region. The UUVs will also observe the behavior of these sources in space and time. Data from UUV platforms and other components of an observatory network in the area will populate the model for initialization, evaluation and optimization of predicting the advective flow of these sources of interest. The interaction between model and observational assets will continue throughout the program ensuring optimization as well as providing guidance for UUV mission planning. The

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model will also include a watershed module with the intention of better quantifying riverine inputs into the local area.

APPROACH

Delft Model: A three-dimensional circulation and transport model DELFT-3D FLOW will be used in this study to predict the advective transport of sources within the study area in Southern California. Tidal, wind-driven and density-driven circulation will be accounted for in the model. The effects of bathymetry, earth's rotation and bed stress are also included. The model is based on the continuity equation and horizontal momentum equation and uses a turbulence closure submodel to adjust mixing rates as function of flow conditions. The model domain is represented by an orthogonal curvilinear mesh in the horizontal and a terrain following ($\sigma-$) coordinate system in the vertical. The model numerics are fully documented in WL Delft Hydraulics (2003) and it has been used to conduct various modeling studies (*i.e.* Hesselink *et al.* 2003; Bielecka and Kazmierski 2003). The model mesh will be developed based the best bathymetry information available that provide comprehensive coverage within the study area. In addition, higher resolution meshes will be developed to best resolve source points of interest. For example, the Tijuana River mouth, two outfall locations as well as beach locations of interest to ONR. The circulation within the finer resolution model will driven by flow (tidal elevations or currents) provided by the coarse model results. The tidal elevation conditions along all open boundaries will be set to available tidal predictions from NOAA (http://tidesonline.nos.noaa.gov/geographic.html) or Xtide (Flater 2006). The number of vertical layers will be determined based on the resolution required and computational considerations.

Environmental Observations with UUVs: As part of this project, observational data sets on regional and local fine scales will be collected by REMUS UUVs. Cal Poly owns and operates two REMUS vehicles with 3,300 km of underwater time and over 170 missions. These deployments have included similar to the AOI for this study; river plumes, surf zone transition areas, dye plumes and outfall plumes. For a description of the vehicles and their applications see Moline *et al.* (2005, 2007). The sensor suite on these vehicles will be used to characterize various sources in the region and track their behavior in time and space. These data will be integrated with the model for improved parameterization of the model and predictive power (see Hibler et al., 2008).

WORK COMPLETED

UUV observations: As part of this effort, REMUS UUVs from Cal Poly and SIO jointly collected CT profiles around the model boundary (see below), and in and around the Tijuana River plume before, during and after storm events. Data were collected in February and March of 2008 and 2009 for a total of 15 missions. These observations were then used by the model for initiation and validation. See http://www.marine.calpoly.edu/auv/REMUS/index.php for Cal Poly depolyments.

Development of a model of a portion of the southern coast of California adjacent to the Tijuana River and San Diego Harbor: A model was developed for the area of interest. Battelle received Southern California NCOM results from UCSD for the period 1/1/2009 to 3/31/2009. These results were requested to provide boundary conditions to the Delft3d-FLOW model applied to the coastal region near the Tijuana River. Battelle collaborated with Deltares to process the NCOM results into forming initial and boundary condition inputs for this finer scale model (Figures 1-5). Comparisons between model output and observations are now being conducted with anticipation of a publication from this effort.

In development of the model there were numerous meetings between ONR, CalPoly, DELFT and SIO to coordinate effort, work with Deltares to modify the model and train SIO on operation of DELFT 3D FLOW.

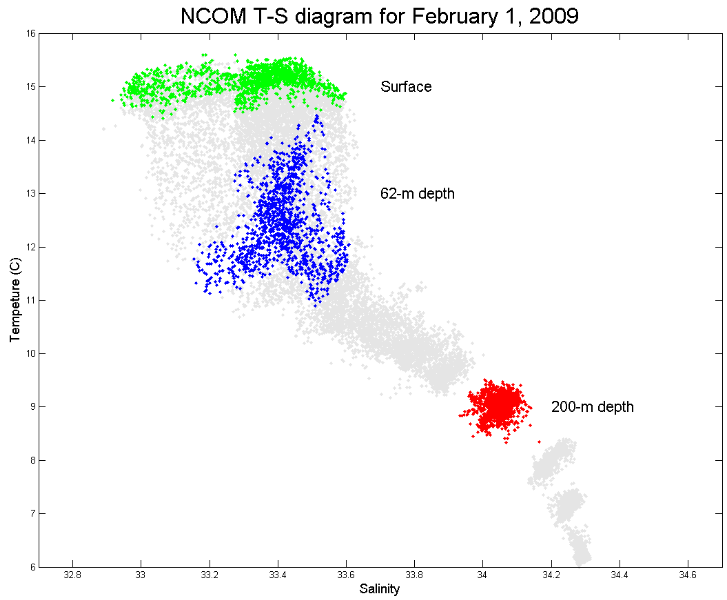

Figure 1. The NCOM modeled temperature and salinity structure off the southern California coast are being used to develop boundary and initial condition for the plume model. This example shows the temperature and salinity provided by NCOM for Midnight February 1, 2009. Only the portion of the NCOM domain near the plume region is used shown in grey. The colors dot show the combination of temperature and salinity associated with the noted depths in the NCOM model.

RESULTS

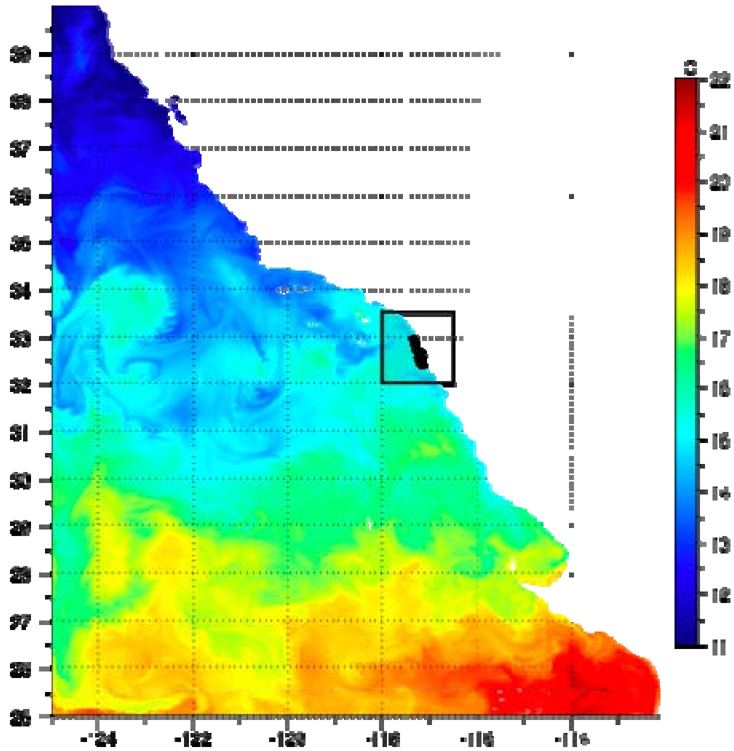

Figure 2. The NCOM modeled surface temperatures for midnight February 1, 2009 are shown. The Delft3d-FLOW plume mesh and that portion of the NCOM results that are directly used to define boundary conditions for the Delft3d-FLOW model are overlaid. A time series of the NCOM results are used to supply boundary conditions to the Delft3d-FLOW model; this figure show one NCOM snapshot.

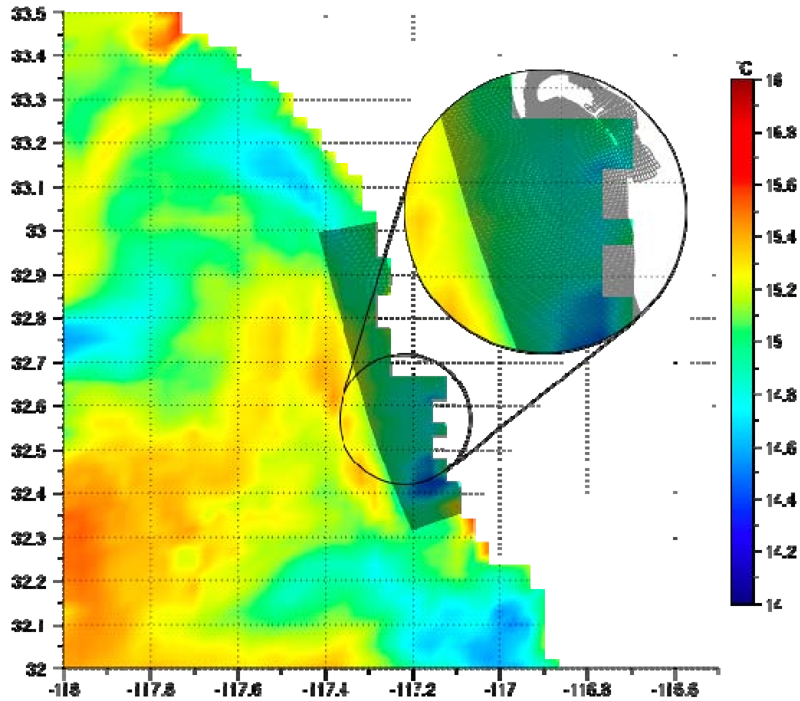

Figure 3. A zoomed in portion of Figure 2 is shown; this shows additional detail of the Delft3d-FLOW mesh and NCOM estimate of the surface temperature for midnight February 1, 2009. This information is update every three hours.

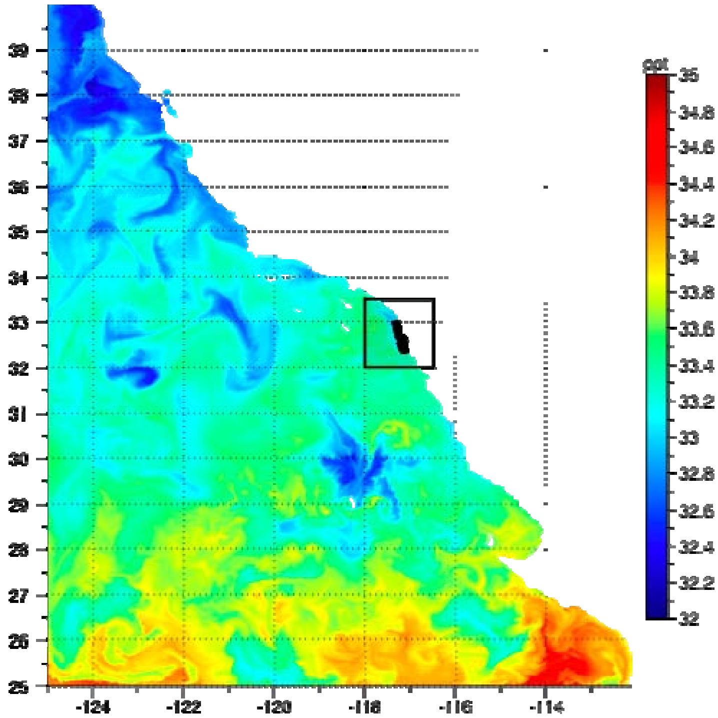

Figure 4. ***The NCOM modeled surface salinities for midnight February 1, 2009 are shown. The Delft3d-FLOW plume mesh and that portion of the NCOM results that are directly used to define boundary conditions for the Delft3d-FLOW model are overlaid. A time series of the NCOM results are used to supply boundary conditions to the Delft3d-FLOW model; this figure show one NCOM snapshot.***

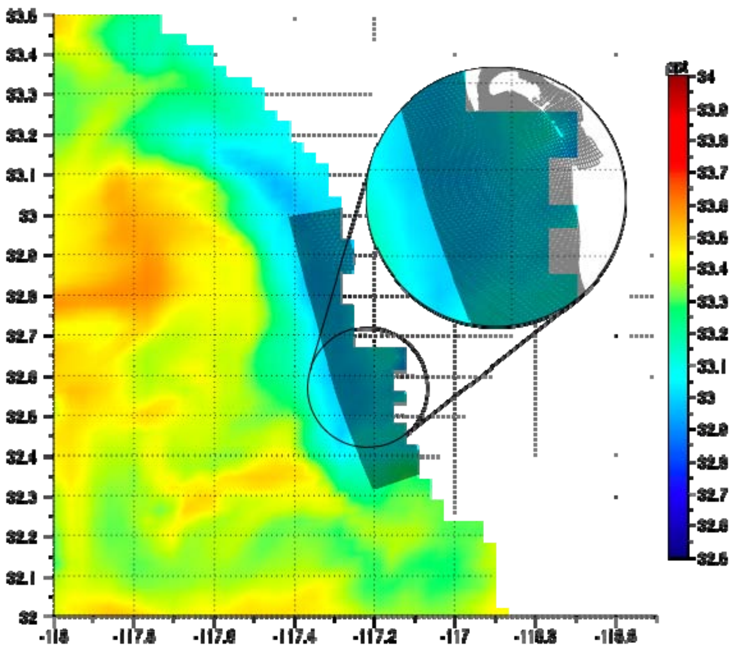

Figure 5. A zoomed in portion of Figure 4 is shown; this shows additional detail of the Delft3d-FLOW mesh and NCOM estimate of the surface salinity for midnight February 1, 2009. This information is update every three hours.

The DELFT-3D FLOW model is now operational and can be run to evaluate the impact of river flow in the coastal area of interest.

IMPACT/APPLICATIONS

These data will advance our understanding of the forcing mechanisms governing the temporal and spatial flow regimes of land-ocean margins and riverine outlets environments, provide a benchmark data set for testing a hydrodynamic model, and provide operational guidance for conducting UUV surveys in regions of complex flows and topography.

TRANSITIONS

None to date

RELATED PROJECTS

This collaboration originated from work done in ONR's Coastal Environmental Effects program (N00014-06-2-0105) and a data-model re-analysis program (N00014-07-1-1113).

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HONORS/AWARDS/PRIZES

Mark A. Moline, named lifetime Fellow of the California Council on Science and Technology